

WHAT IS CLAIMED IS:

1. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems,

the method comprising:

inputting multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said microphones through the audio transfer systems;

estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones said the multi-channel audio signals to be reproduced by said respective loudspeakers or a plurality of composite signals obtained by suitably combining said multi-channel audio signals; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said one or plurality of microphones, or from a plurality of composite signals obtained by suitably combining said individual collected audio signals, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower  
5 correlation with each other than that among said multi-channel audio signals, for deriving said individual transfer functions of the respective audio transfer systems or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions,  
10 thereby setting said corresponding filter characteristics.

2. A multi-channel echo cancel method as recited in claim 1, wherein calculation is conducted for respectively deriving the individual transfer functions of the respective  
15 audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a  
20 cross-spectrum calculation between the plurality of the low-correlation composite signals and the individual collected audio signals of the microphones, or the plurality of the composite signals obtained by suitably combining said individual collected audio signals.

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3. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and

one or a plurality of microphones for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are collected by said  
5 microphones,

the method comprising: estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer  
10 functions so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by  
15 said respective loudspeakers or a plurality of composite signals obtained by suitably combining said multi-channel audio signals; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said one  
20 or plurality of microphones, or from a plurality of composite signals obtained by suitably combining said individual collected audio signals, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which  
25 correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-

channel audio signals, for deriving said individual transfer functions of the respective audio transfer systems or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions,

5 thereby setting said corresponding filter characteristics,

wherein calculation is conducted for respectively deriving the individual transfer functions of the respective audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said

10 individual transfer functions with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum calculation between the plurality of the low-correlation composite signals and the individual collected  
15 audio signals of the microphones, or the plurality of the composite signals obtained by suitably combining said individual collected audio signals, and wherein

the calculation of respectively deriving the individual transfer functions of said plurality of the audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions is performed by combining said multi-channel audio signals through addition or subtraction to produce a plurality of low-correlation composite signals

25 having a lower correlation with each other than that among said multi-channel audio signals, deriving cross spectra by the cross-spectrum calculation between said plurality of the

low-correlation composite signals and the individual collected audio signals of the microphones, or the plurality of the composite signals obtained by suitably combining said individual collected audio signals, and ensemble-averaging each of the cross spectra in a predetermined time period for deriving the individual transfer functions of said plurality of the audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions.

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4. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems,

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the method comprising:

inputting multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said microphones through the audio transfer systems;

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estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions so as to set corresponding filter characteristics, respectively;

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producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by

said respective loudspeakers or a plurality of composite signals obtained by suitably combining said multi-channel audio signals; and

subtracting said echo cancel signals from  
5 corresponding individual collected audio signals of said one or plurality of microphones, or from a plurality of composite signals obtained by suitably combining said individual collected audio signals, thereby performing echo cancellation,

wherein, reference signals are determined as a set  
10 of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving estimated errors of said  
15 individual transfer functions of the respective audio transfer systems or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions, thereby updating said corresponding filter characteristics to values that cancel the estimated  
20 errors.

5. A multi-channel echo cancel method as recited in claim 4, wherein calculation is conducted for respectively deriving the estimated errors of the individual transfer  
25 functions of the respective audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions with

using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum calculation between the plurality of the low-correlation composite signals and echo cancel error signals obtained by subtracting the echo cancel signals from the corresponding individual collected audio signals of said one or plurality of the microphones, or from the plurality of the composite signals obtained by suitably combining said individual collected audio signals.

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6. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are collected by said microphones,

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the method comprising: estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions so as to set corresponding filter characteristics, respectively;

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producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by said respective loudspeakers or a plurality of composite

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signals obtained by suitably combining said multi-channel audio signals; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said one or plurality of microphones, or from a plurality of composite signals obtained by suitably combining said individual collected audio signals, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving estimated errors of said individual transfer functions of the respective audio transfer systems or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions, thereby updating said corresponding filter characteristics to values that cancel the estimated errors,

wherein calculation is conducted for respectively deriving the estimated errors of the individual transfer functions of the respective audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions with using the set of the plurality of the low-correlation composite signals as the reference signals, such that the calculation is based on a cross-spectrum calculation between



the plurality of the low-correlation composite signals and echo cancel error signals obtained by subtracting the echo cancel signals from the corresponding individual collected audio signals of said one or plurality of the microphones, or  
5 from the plurality of the composite signals obtained by suitably combining said individual collected audio signals, and

wherein the calculation of respectively deriving the estimated errors of the individual transfer functions of said  
10 plurality of the audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions is performed by combining said multi-channel audio signals through addition or subtraction to produce a plurality of low-correlation  
15 composite signals having a lower correlation with each other than that among said multi-channel audio signals, deriving cross spectra by the cross-spectrum calculation between said plurality of the low-correlation composite signals and the echo cancel error signals obtained by subtracting the echo  
20 cancel signals from the corresponding individual collected audio signals of said one or plurality of the microphones, or from the plurality of the composite signals obtained by suitably combining said individual collected audio signals, and ensemble-averaging each of the cross spectra in a  
25 predetermined time period for deriving the estimated errors of the individual transfer functions of said plurality of the audio transfer systems or the plurality of the composite

transfer functions obtained by suitably combining said individual transfer functions.

7. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are collected by said microphones,

the method comprising: estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said set filter characteristics to corresponding ones of said multi-channel audio signals to be reproduced by said respective loudspeakers or a plurality of composite signals obtained by suitably combining said multi-channel audio signals; and

subtracting said echo cancel signals from corresponding individual collected audio signals of said one or plurality of microphones, or from a plurality of composite signals obtained by suitably combining said individual collected audio signals, thereby performing echo cancellation,

wherein, reference signals are determined as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that among said multi-channel audio signals, for deriving estimated errors of said individual transfer functions of the respective audio transfer systems or said plurality of said composite transfer functions obtained by suitably combining said individual transfer functions, thereby updating said corresponding filter characteristics to values that cancel the estimated errors, and

wherein the correlation between said plurality of said low-correlation composite signals is detected and, when a value of said correlation is no less than a predetermined value, the updating of said filter characteristics is suspended.

8. A multi-channel sound transfer method associated to two spaces each forming said plurality of said audio transfer systems, wherein the multi-channel echo cancel method recited in claim 1 is carried out respectively in the two spaces, so that the multi-channel audio signals, which have been echo-canceled by performing said method, are transmitted between said two spaces.

9. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and

one or a plurality of microphones for forming a plurality of audio transfer systems,

the method comprising:

inputting multi-channel audio signals from an

5 outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said microphones through the audio transfer systems;

10 estimating transfer functions of said plurality of said audio transfer systems so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said filter characteristics to corresponding multi-channel audio signals to be reproduced by said respective loudspeakers; and

15 subtracting said echo cancel signals from corresponding collected audio signals of said one or plurality of said microphones, thereby performing echo cancellation,

20 wherein a principal component analysis is applied to said multi-channel audio signals to produce a plurality of uncorrelated composite signals that are orthogonal to each other, and the transfer functions of the respective audio transfer systems are respectively derived using a set of said plurality of said uncorrelated composite signals as reference  
25 signals, thereby to set the corresponding filter characteristics.

10. A multi-channel echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems,

5 the method comprising:

inputting multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers and collected by said microphones through the audio transfer systems;

10 estimating transfer functions of said plurality of said audio transfer systems so as to set corresponding filter characteristics, respectively;

producing echo cancel signals respectively by applying said filter characteristics to corresponding multi-channel audio signals to be reproduced by said respective loudspeakers; and

15 subtracting said echo cancel signals from corresponding collected audio signals of said one or plurality of said microphones, thereby performing echo cancellation,

20 wherein a principal component analysis is applied to said multi-channel audio signals to produce a plurality of uncorrelated composite signals that are orthogonal to each other, and estimated errors of the transfer functions of the respective audio transfer systems are respectively derived

25 using a set of said plurality of said uncorrelated composite signals as reference signals, thereby to update said

corresponding filter characteristics to values that cancel said estimated errors.

11. A stereo echo canceller associated to a space  
5 provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter  
10 sections that are provided corresponding to the first and second microphones for subjecting an audio signal supplied to the first loudspeaker to convolution calculations so as to produce first and second echo cancel signals, respectively;

third and fourth filter sections that are provided  
15 corresponding to the first and second microphones for subjecting another audio signal supplied to the second loudspeaker to convolution calculations so as to produce third and fourth echo cancel signals, respectively;

a first subtracting section that performs echo  
20 cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first microphone; and

a second subtracting section that performs echo  
cancellation by subtracting said second and fourth echo  
25 cancel signals from another collected audio signal of the second microphone, wherein

said stereo echo canceller further comprises a

transfer function calculating section that respectively  
derives filter characteristics corresponding to transfer  
functions of said four audio transfer systems based on a  
cross-spectrum calculation between a sum signal and  
5 difference signal of stereo audio signals to be reproduced by  
said respective loudspeakers and the collected audio signals  
of said respective microphones, thereby to set said derived  
filter characteristics to corresponding ones of said first to  
fourth filter sections, respectively.

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12. A stereo echo canceller as recited in claim 11,  
further comprising:

an input section that inputs said stereo audio  
signals;

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a sum/difference signal producing section that  
produces said sum signal and said difference signal of the  
stereo audio signals inputted from said input section; and

a main signal transmission system that transmits the  
stereo audio signals inputted from said input section to said  
20 respective loudspeakers without passing through said  
sum/difference signal producing section,

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wherein said transfer function calculating section  
derives the filter characteristics corresponding to the  
transfer functions of said four audio transfer systems based  
25 on the cross-spectrum calculation between the sum signal and  
difference signal produced by said sum/difference signal  
producing section and the collected audio signals of said

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respective microphones, and sets the derived filter characteristics to corresponding ones of said first to fourth filter sections, respectively.

5        13.        A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

10                the canceller comprising: first and second filter sections that are provided corresponding to the first and second microphones for subjecting an audio signal supplied to the first loudspeaker to convolution calculations so as to produce first and second echo cancel signals, respectively;

15                third and fourth filter sections that are provided corresponding to the first and second microphones for subjecting another audio signal supplied to the second loudspeaker to convolution calculations so as to produce third and fourth echo cancel signals, respectively;

20                a first subtracting section performs echo cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first microphone; and

25                a second subtracting section that performs echo cancellation by subtracting said second and fourth echo cancel signals from another collected audio signal of the second microphone, wherein



said stereo echo canceller further comprises a transfer function calculating section respectively derives estimated errors of transfer functions of said four audio transfer systems based on a cross-spectrum calculation  
5 between respective one of a sum signal and a difference signal of stereo audio signals to be reproduced by said respective loudspeakers and respective one of echo cancel error signals obtained by subtracting the corresponding echo cancel signals from the collected audio signals of said two  
10 microphones, thereby to update filter characteristics of said first to fourth filter sections to values that cancel said estimated errors, respectively.

14. A stereo echo canceller as recited in claim 13,  
15 further comprising:

an input section that inputs said stereo audio signals;

a sum/difference signal producing section that produces said sum signal and said difference signal of the  
20 stereo audio signals inputted from said input section; and

a main signal transmission system that transmits the stereo audio signals inputted from said input section to said respective loudspeakers without passing through said sum/difference signal producing section,

25 wherein said transfer function calculating section derives the estimated errors of the transfer functions of said four audio transfer systems based on the cross-spectrum

calculation between the sum signal and difference signal  
produced by said sum/difference signal producing section and  
the respective echo cancel error signals, and updates the  
filter characteristics of said first to fourth filter  
5 sections to the values that cancel said estimated errors,  
respectively.

15. A stereo echo canceller as recited in claim 13,  
further comprising a correlation detecting section that  
10 detects a correlation between the sum signal and the  
difference signal of said stereo audio signals, and that  
stops the updating of said filter characteristics when a  
value of said correlation is no less than a predetermined  
value.

15 16. A stereo echo canceller associated to a space  
provided therein with two loudspeakers and two microphones  
for forming four audio transfer systems,

the canceller comprising:

20 an input section that inputs audio signals of stereo  
sounds from an outside, which are reproduced by said  
respective loudspeakers and collected by said respective  
microphones through the audio transfer systems;

25 first and second filter sections that is provided  
corresponding to the first and second microphones for  
subjecting an audio signal supplied to the first loudspeaker  
to convolution calculations so as to produce first and second

echo cancel signals, respectively;

third and fourth filter sections that are provided corresponding to the first and second microphones for subjecting another audio signal supplied to the second  
5 loudspeaker to convolution calculations so as to produce third and fourth echo cancel signals, respectively;

a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first  
10 microphone; and

a second subtracting section that performs echo cancellation by subtracting said second and fourth echo cancel signals from another collected audio signal of the second microphone, wherein

15 said stereo echo canceller further comprises a transfer function calculating section respectively derives filter characteristics corresponding to transfer functions of said four audio transfer systems based on a cross-spectrum calculation between said collected audio signals of said  
20 respective microphones and mutually orthogonal two uncorrelated composite signals produced by applying a principal component analysis to stereo audio signals to be reproduced by said respective loudspeakers, thereby to set said derived filter characteristics to corresponding ones of  
25 said first to fourth filter sections, respectively.

17. A stereo echo canceller as recited in claim 16,

further comprising:

an orthogonalizing section that applies said principal component analysis to the stereo audio signals inputted from said input section to produce said mutually  
5 orthogonal two uncorrelated composite signals; and

a main signal transmission system that transmits the stereo audio signals inputted from said input section to said respective loudspeakers without passing through said orthogonalizing section,

10 wherein said transfer function calculating section derives the filter characteristics corresponding to the transfer functions of said four audio transfer systems based on the cross-spectrum calculation between the two uncorrelated composite signals produced by said  
15 orthogonalizing section and the collected audio signals of said respective microphone, and sets the derived filter characteristics to corresponding ones of said first to fourth filter sections, respectively.

20 18. A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems,

the canceller comprising:

an input section that inputs stereo audio signals  
25 from an outside, which are reproduced by said respective loudspeakers and collected by said respective microphones through the audio transfer systems;

first and second filter sections that are provided  
corresponding to the first and second microphones for  
subjecting an audio signal supplied to the first loudspeaker  
to convolution calculations so as to produce first and second  
5 echo cancel signals, respectively;

third and fourth filter sections that are provided  
corresponding to the first and second microphones for  
subjecting another audio signal supplied to the second  
loudspeaker to convolution calculations so as to produce  
10 third and fourth echo cancel signals, respectively;

a first subtracting section performs echo  
cancellation by subtracting said first and third echo cancel  
signals from a collected audio signal of the first  
microphone; and

15 a second subtracting section performs echo  
cancellation by subtracting said second and fourth echo  
cancel signals from another collected audio signal of the  
second microphone, wherein

said stereo echo canceller further comprises a  
20 transfer function calculating section that respectively  
derives estimated errors of transfer functions of said four  
audio transfer systems based on a cross-spectrum calculation  
between mutually orthogonal two uncorrelated composite  
signals produced by applying a principal component analysis  
25 to stereo audio signals to be reproduced by said respective  
loudspeakers and respective echo cancel error signals  
obtained by subtracting the corresponding echo cancel signals

from the collected audio signals of said two microphones, thereby to update filter characteristics of said first to fourth filter sections to values that cancel said estimated errors, respectively.

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19. A stereo echo canceller as recited in claim 18, further comprising:

an orthogonalizing section applies a principal component analysis to the stereo audio signals inputted from said input section to produce said mutually orthogonal two uncorrelated composite signals; and

a main signal transmission system that transmits the stereo audio signals inputted from said input section to said respective loudspeakers without passing through said orthogonalizing section,

wherein said transfer function calculating section derives the estimated errors of the transfer functions of said four audio transfer systems based on the cross-spectrum calculation between the two uncorrelated composite signals produced by said orthogonalizing section and the respective echo cancel error signals, and updates the filter characteristics of said first to fourth filter sections to the values that cancel said estimated errors, respectively.

20. A stereo echo canceller as recited in claim 18, further comprising a double talk detecting section that is provided for detecting double talk in which a sound other

than that reproduced by said loudspeakers is inputted into said microphones,

wherein said transfer function calculating section makes relatively longer an update period of said filter characteristics when said double talk is detected, while makes relatively shorter the update period of said filter characteristics when said double talk is not detected.

21. A stereo sound transfer apparatus associated to two spaces each forming said four audio transfer systems, wherein the stereo echo canceller recited in claim 11 is arranged in each space, so that the stereo audio signals, which have been echo-canceled by said stereo echo cancellers, are transmitted between said two spaces.

22. A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter sections that are provided for subjecting a sum signal of stereo audio signals to be reproduced by said respective loudspeakers to convolution calculations respectively, so as to produce first and second echo cancel signals;

third and fourth filter sections that are provided for subjecting a difference signal of the stereo audio

signals to be reproduced by said respective loudspeakers to convolution calculations respectively, so as to produce third and fourth echo cancel signals;

5 a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first microphone; and

10 a second subtracting section that performs echo cancellation subtracting said second and fourth echo cancel signals from another collected audio signal of the second microphone,

wherein said stereo echo canceller further comprises a transfer function calculating section respectively derives filter characteristics corresponding to composite transfer  
15 functions of said four audio transfer systems based on a cross-spectrum calculation between the sum signal and difference signal of the stereo audio signals to be reproduced by said respective loudspeakers and the collected audio signals of said respective microphones, thereby to set  
20 said derived filter characteristics to corresponding ones of said first to fourth filter sections, respectively.

23. A stereo echo canceller as recited in claim 22, further comprising:

25 an input section that inputs said stereo audio signals;

a sum/difference signal producing section that



produces said sum signal and difference signal of the stereo audio signals inputted from said input section; and

a main signal transmission system that transmits the stereo audio signals inputted from said input section to said  
5 respective loudspeakers without passing through said sum/difference signal producing section,

wherein said transfer function calculating section derives the filter characteristics corresponding to the composite transfer functions of said four audio transfer  
10 systems based on the cross-spectrum calculation between the sum signal and difference signal produced by said sum/difference signal producing section and the collected audio signals of said respective microphones, and sets the derived filter characteristics to corresponding ones of said  
15 first to fourth filter sections, respectively.

24. A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo  
20 sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter sections that subjects a sum signal of stereo audio signals to be reproduced by said respective loudspeakers to  
25 convolution calculations respectively, so as to produce first and second echo cancel signals;

third and fourth filter sections that subjects a

difference signal of the stereo audio signals to be reproduced by said respective loudspeakers to convolution calculations respectively, so as to produce third and fourth echo cancel signals;

5           a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a collected audio signal of the first microphone; and

10           a second subtracting section that performs echo cancellation by subtracting, said second and fourth echo cancel signals from another collected audio signal of the second microphone, wherein

15           said stereo echo canceller further comprises a transfer function calculating section that respectively derives estimated errors of composite transfer functions of said four audio transfer systems based on a cross-spectrum calculation between the sum signal and difference signal of the stereo audio signals to be reproduced by said respective loudspeakers and respective echo cancel error signals  
20           obtained by subtracting the corresponding echo cancel signals from the collected audio signals of said two microphones, thereby to update filter characteristics of said first to fourth filter sections to values that cancel said estimated errors, respectively.

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25.       A stereo echo canceller as recited in claim 24, further comprising:

an input section that inputs said stereo audio signals;

a sum/difference signal producing section that produces said sum signal and difference signal of the stereo audio signals inputted from said input section; and

a main signal transmission system that transmits the stereo audio signals inputted from said input section to said respective loudspeakers without passing through said sum/difference signal producing section,

wherein said transfer function calculating section derives the estimated errors of the composite transfer functions of said four audio transfer systems based on the cross-spectrum calculation between the sum signal and difference signal produced by said sum/difference signal producing section and the respective echo cancel error signals, and updates the filter characteristics of said first to fourth filter sections to the values that cancel said estimated errors, respectively.

26. A stereo echo canceller as recited in claim 24, further comprising a correlation detecting section that is provided for detecting a correlation between the sum signal and the difference signal of said stereo audio signals, and for stopping the updating of said filter characteristics when a value of said correlation is no less than a predetermined value.

27. A stereo sound transfer apparatus associated to two spaces each forming said four audio transfer systems, wherein the stereo echo canceller recited in claim 22 is arranged in each space, so that the stereo audio signals, which have been  
5 echo-canceled by said stereo echo cancellers, are transmitted between said two spaces.

28. A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones  
10 for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter sections that subject an audio signal supplied to the first  
15 loudspeaker to convolution calculations respectively, so as to produce first and second echo cancel signals;

third and fourth filter sections that subject another audio signal supplied to the second loudspeaker to convolution calculations respectively, so as to produce third  
20 and fourth echo cancel signals;

a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a sum signal of collected audio signals of the respective microphones; and

25 a second subtracting section that performs echo cancellation subtracting said second and fourth echo cancel signals from a difference signal of the collected audio

signals of the respective microphones, wherein

5       said stereo echo canceller further comprises a  
transfer function calculating section that respectively  
derives filter characteristics corresponding to composite  
transfer functions of said four audio transfer systems based  
on a cross-spectrum calculation between a sum signal and  
difference signal of stereo audio signals to be reproduced by  
said respective loudspeakers and the sum signal and  
difference signal of the collected audio signals of said  
10       respective microphones, thereby to set said derived filter  
characteristics to corresponding ones of said first to fourth  
filter sections, respectively.

29.       A stereo echo canceller associated to a space  
15       provided therein with two loudspeakers and two microphones  
for forming four audio transfer systems through which stereo  
sounds are reproduced by said respective loudspeakers and are  
collected by said respective microphones,

20       the canceller comprising: first and second filter  
sections that subject an audio signal supplied to the first  
loudspeaker to convolution calculations so as to produce  
first and second echo cancel signals;

25       third and fourth filter sections that subject  
another audio signal supplied to the second loudspeaker to  
convolution calculations respectively, so as to produce third  
and fourth echo cancel signals;

first subtracting section that performs echo

cancellation by subtracting said first and third echo cancel signals from a sum signal of collected audio signals of the respective microphones; and

second subtracting section that performs echo  
5 cancellation by subtracting said second and fourth echo cancel signals from a difference signal of the collected audio signals of the respective microphones, wherein

said stereo echo canceller further comprises a transfer function calculating section that respectively  
10 derives estimated errors of composite transfer functions of said four audio transfer systems based on a cross-spectrum calculation between a sum signal and difference signal of stereo audio signals to be reproduced by said respective loudspeakers and respective echo cancel error signals  
15 obtained by subtracting the corresponding echo cancel signals from the sum signal and difference signal of the collected audio signals of said respective microphones, thereby to update filter characteristics of said first to fourth filter sections to values that cancel said estimated errors,  
20 respectively.

30. A stereo echo canceller as recited in claim 29, further comprising a correlation detecting section that is provided for detecting a correlation between the sum signal  
25 and the difference signal of said stereo audio signals, and for stopping the updating of said filter characteristics when a value of said correlation is no less than a predetermined

value.

31. A stereo sound transfer apparatus associated to two spaces each forming said four audio transfer systems, wherein the stereo echo canceller recited in claim 28 is arranged in each space, so that the stereo audio signals, which have been echo-canceled by said stereo echo cancellers, are transmitted between said two spaces.

32. A stereo echo canceller associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems through which stereo sounds are reproduced by said respective loudspeakers and are collected by said respective microphones,

the canceller comprising: first and second filter sections that subject a sum signal of stereo audio signals to be reproduced by said respective loudspeakers to convolution calculations respectively, so as to produce first and second echo cancel signals;

third and fourth filter sections that subject a difference signal of the stereo audio signals to be reproduced by said respective loudspeakers to convolution calculations respectively, so as to produce third and fourth echo cancel signals;

a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a sum signal of collected audio signals of the

respective microphones; and

a second subtracting section that performs echo  
cancellation by subtracting said second and fourth echo  
cancel signals from a difference signal of the collected  
5 audio signals of the respective microphones, wherein

said stereo echo canceller further comprises a  
transfer function calculating section that respectively  
derives filter characteristics corresponding to composite  
transfer functions of said four audio transfer systems based  
10 on a cross-spectrum calculation between the sum signal and  
difference signal of the stereo audio signals to be  
reproduced by said respective loudspeakers and the sum signal  
and difference signal of the collected audio signals of the  
respective microphones, thereby to set said derived filter  
15 characteristics to corresponding ones of said first to fourth  
filter sections, respectively.

33. A stereo echo canceller associated to a space  
provided therein with two loudspeakers and two microphones  
20 for forming four audio transfer systems through which stereo  
sounds are reproduced by said respective loudspeakers and are  
collected by said respective microphones,

the canceller comprising: first and second filter  
sections that subject a sum signal of stereo audio signals to  
25 be reproduced by said respective loudspeakers to convolution  
calculations respectively, so as to produce first and second  
echo cancel signals;



third and fourth filter sections that subject a difference signal of the stereo audio signals to be reproduced by said respective loudspeakers to convolution calculations respectively, so as to produce third and fourth  
5 echo cancel signals;

a first subtracting section that performs echo cancellation by subtracting said first and third echo cancel signals from a sum signal of collected audio signals of the respective microphones; and

10 a second subtracting section that performs echo cancellation by subtracting said second and fourth echo cancel signals from a difference signal of the collected audio signals of the respective microphones, wherein

said stereo echo canceller further comprises a  
15 transfer function calculating section that respectively derives estimated errors of composite transfer functions of said four audio transfer systems based on a cross-spectrum calculation between the sum signal and difference signal of the stereo audio signals to be reproduced by said respective  
20 loudspeakers and respective echo cancel error signals obtained by subtracting the corresponding echo cancel signals from the sum signal and the difference signal of the collected audio signals of the respective microphones, thereby to update filter characteristics of said first to  
25 fourth filter sections to values that cancel said estimated errors, respectively.

34. A stereo echo canceller as recited in claim 33,  
further comprising a correlation detecting section that is  
provided for detecting a correlation between the sum signal  
and the difference signal of said stereo audio signals, and  
5 for stopping the updating of said filter characteristics when  
a value of said correlation is no less than a predetermined  
value.

35. A stereo sound transfer apparatus associated to two  
10 spaces each forming said four audio transfer systems, wherein  
the stereo echo canceller recited in claim 32 is arranged in  
each space, so that the stereo audio signals, which have been  
echo-canceled by said stereo echo cancellers, are transmitted  
between said two spaces.

15 36. A transfer function calculation apparatus being  
associated to a space provided therein with a plurality of  
loudspeakers and one or a plurality of microphones for  
forming a plurality of audio transfer systems, and being  
20 capable of estimating individual transfer functions of said  
plurality of audio transfer systems or a plurality of  
composite transfer functions obtained by suitably combining  
said individual transfer functions, the apparatus comprising:

25 an input section that inputs multi-channel audio  
signals from an outside, which have a correlation with each  
other, and which are reproduced by said respective  
loudspeakers and collected by said microphones through the

audio transfer systems;

a providing section that provides reference signals as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that between said multi-channel audio signals; and

a calculation section that estimates the individual transfer functions of the respective audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions based on the determined reference signals.

37. A transfer function calculation apparatus as recited in claim 36, wherein the calculation section respectively derives the individual transfer functions of the respective audio transfer systems or the plurality of said composite transfer functions obtained by suitably combining said individual transfer functions, using as the reference signals the set of the plurality of the low-correlation composite signals, such that calculation of respectively deriving the individual transfer functions of the respective audio transfer systems or the plurality of said composite transfer functions obtained by suitably combining said individual transfer functions is based on a cross-spectrum calculation between the plurality of said low-correlation composite signals and individual collected audio signals of the

microphones, or a plurality of composite signals obtained by suitably combining said individual collected audio signals.

38. A transfer function calculation apparatus being  
5 associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems through which multi-channel audio signals having a correlation with each other are reproduced by said respective loudspeakers and are  
10 collected by said microphones, and being capable of estimating individual transfer functions of said plurality of audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions, the apparatus comprising:

15 a providing section that provides reference signals as a set of a plurality of low-correlation composite signals which correspond to signals obtained by suitably combining said multi-channel audio signals and which have a lower correlation with each other than that between said multi-  
20 channel audio signals; and

a calculation section that estimates the individual transfer functions of the respective audio transfer systems or the plurality of the composite transfer functions obtained by suitably combining said individual transfer functions  
25 based on the determined reference signals,

wherein the calculation section respectively derives the individual transfer functions of the respective audio

transfer systems or the plurality of said composite transfer functions obtained by suitably combining said individual transfer functions, using as the reference signals the set of the plurality of the low-correlation composite signals, such that calculation of respectively deriving the individual transfer functions of the respective audio transfer systems or the plurality of said composite transfer functions obtained by suitably combining said individual transfer functions is based on a cross-spectrum calculation between the plurality of said low-correlation composite signals and individual collected audio signals of the microphones, or a plurality of composite signals obtained by suitably combining said individual collected audio signals, and

wherein the providing section combines said multi-channel audio signals through addition or subtraction to produce said plurality of said low-correlation composite signals having a lower correlation with each other than that between said multi-channel audio signals, such that the calculation section derives cross spectra based on said cross-spectrum calculation between said plurality of said low-correlation composite signals and the individual collected audio signals of the microphones, or the plurality of composite signals obtained by suitably combining said individual collected audio signals, and ensemble-averages the respective cross spectra in a predetermined time period for deriving the individual transfer functions of said plurality of said audio transfer systems or the plurality of said

composite transfer functions obtained by suitably combining said individual transfer functions.

39. A transfer function calculation apparatus as recited  
5 in claim 37, wherein the providing section produces a plurality of uncorrelated composite signals mutually orthogonal as the reference signals by applying a principal component analysis to said multi-channel audio signals, such that the calculation section derives cross spectra based on  
10 said cross-spectrum calculation between said plurality of said uncorrelated composite signals and the individual collected audio signals of the microphones, and ensemble-averages the respective cross spectra in a predetermined time period for deriving the individual transfer functions of said  
15 plurality of said audio transfer systems.

40. A transfer function calculation apparatus being associated to a space provided therein with two loudspeakers and two microphones for forming four audio transfer systems,  
20 and being capable of estimating individual transfer functions of said four audio transfer systems, the apparatus comprising:

a section that inputs stereo audio signals from an outside, which are reproduced by said respective loudspeakers  
25 and collected by said respective microphones;

a section that produces mutually orthogonal two uncorrelated composite signals by applying a principal

component analysis to said stereo audio signals; and

a section that estimates said individual transfer functions of said four audio transfer systems using a set of said two uncorrelated composite signals as reference signals.

5

41. An echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems through which audio signals of multi-

10 channels having a correlation with each other are reproduced by said respective loudspeakers and are collected by said microphones, and designed for performing an echo cancellation by subtracting an echo cancel signal from the audio signals collected by the respective microphone or from composite  
15 signals obtained by combining the collected audio signals, the method comprising:

inputting a plurality of low-correlation audio signals which are obtained by suitably combining first audio signals of multi-channels and which have a lower correlation  
20 with each other than that among said first audio signals of multi-channels;

generating second audio signals of multi-channels having a correlation with each other by computation based on the inputted low-correlation audio signals;

25 feeding the generated second audio signals to the respective loudspeakers so as to reproduce audio sounds;

feeding the generated second audio signals or the

inputted low-correlation audio signals to filters;

estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions based on the inputted low-correlation audio signals so as to set corresponding filter characteristics;

producing echo cancel signals by applying said set filter characteristics to the second audio signals or the low-correlation audio signals fed to the filters; and

subtracting said echo cancel signals from collected audio signals obtained by collecting the reproduced audio sounds by the microphones or from composite audio signals obtained by suitably combining said collected audio signals, thereby performing the echo cancellation.

42. An echo cancel method as recited in claim 41, wherein the inputted low-correlation audio signals are obtained by adding or subtracting the first audio signals of multi-channels with each other.

43. An echo cancel method associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio transfer systems through which audio signals of multi-channels having a correlation with each other are reproduced by said respective loudspeakers and are collected by said



microphones, and designed for performing an echo cancellation by subtracting an echo cancel signal from the audio signals collected by the respective microphone or from composite signals obtained by combining the collected audio signals,  
5 the method comprising:

inputting a plurality of first low-correlation audio signals which are obtained by suitably combining first audio signals of multi-channels and which have a lower correlation with each other than that among said first audio signals of  
10 multi-channels;

generating second audio signals of multi-channels having a correlation with each other by computation based on the inputted first low-correlation audio signals;

feeding the generated second audio signals to the  
15 respective loudspeakers so as to reproduce audio sounds;

generating second low-correlation audio signals of multi-channels based on the generated second audio signals;

feeding the generated second audio signals or the generated second low-correlation audio signals to filters;

20 estimating individual transfer functions of said plurality of said audio transfer systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions based on the generated second low-correlation audio signals so as to set

25 corresponding filter characteristics;

producing echo cancel signals by applying said set filter characteristics to the second audio signals or the

second low-correlation audio signals fed to the filters; and  
subtracting said echo cancel signals from collected  
audio signals obtained by collecting the reproduced audio  
sounds at the microphones or from composite audio signals  
5 obtained by suitably combining said collected audio signals,  
thereby performing the echo cancellation.

44. An echo cancel method as recited in claim 43,  
wherein the inputted first low-correlation audio signals are  
10 obtained by adding or subtracting the first audio signals of  
multi-channels with each other.

45. An echo canceller associated to a space provided  
therein with a plurality of loudspeakers and one or a  
15 plurality of microphones for forming a plurality of audio  
transfer systems through which audio signals of multi-  
channels having a correlation with each other are reproduced  
by said respective loudspeakers and are collected by said  
microphones, and designed for performing an echo cancellation  
20 by subtracting an echo cancel signal from the audio signals  
collected by the respective microphone or from composite  
signals obtained by combining the collected audio signals,  
the echo canceller comprising:

an inputting section that inputs a plurality of low-  
25 correlation audio signals which are obtained by suitably  
combining first audio signals of multi-channels and which  
have a lower correlation with each other than that among said

first audio signals of multi-channels;

a demodulating section that is provided for generating second audio signals of multi-channels having a correlation with each other by demodulating the inputted low-correlation audio signals, and for feeding the generated  
5 second audio signals to the respective loudspeakers so as to reproduce audio sounds;

an estimating section that estimates individual transfer functions of said plurality of said audio transfer  
10 systems or a plurality of composite transfer functions obtained by suitably combining said individual transfer functions based on the inputted low-correlation audio signals so as to set corresponding filter characteristics;

a filter section that produces echo cancel signals  
15 by applying said set filter characteristics to the second audio signals or the low-correlation audio signals fed to the filter section; and

a subtracting section that subtracts said echo cancel signals from collected audio signals obtained by  
20 collecting the reproduced audio sounds at the microphones or from composite audio signals obtained by suitably combining said collected audio signals, thereby performing the echo cancellation.

25 46. An echo canceller as recited in claim 45, wherein the inputted low-correlation audio signals are obtained by adding or subtracting the first audio signals of multi-

channels with each other.

47. An echo canceller associated to a space provided therein with a plurality of loudspeakers and one or a  
5 plurality of microphones for forming a plurality of audio transfer systems through which audio signals of multi-channels having a correlation with each other are reproduced by said respective loudspeakers and are collected by said microphones, and designed for performing an echo cancellation  
10 by subtracting an echo cancel signal from the audio signals collected by the respective microphone or from composite signals obtained by combining the collected audio signals, the echo canceller comprising:

an inputting section that inputs a plurality of  
15 first low-correlation audio signals which are obtained by suitably combining first audio signals of multi-channels and which have a lower correlation with each other than that among said first audio signals of multi-channels;

a demodulating section that is provided for  
20 generating second audio signals of multi-channels having a correlation with each other by demodulating the inputted first low-correlation audio signals, and for feeding the generated second audio signals to the respective loudspeakers so as to reproduce audio sounds;

25 an estimating section that is provided for generating second low-correlation audio signals of multi-channels based on the generated second audio signals, and for

estimating individual transfer functions of said plurality of  
said audio transfer systems or a plurality of composite  
transfer functions obtained by suitably combining said  
individual transfer functions based on the generated second  
5 low-correlation audio signals so as to set corresponding  
filter characteristics;

a filter section that produces echo cancel signals  
by applying said set filter characteristics to the second  
audio signals or the second low-correlation audio signals fed  
10 to the filter section; and

a subtracting section that subtracts said echo  
cancel signals from collected audio signals obtained by  
collecting the reproduced audio sounds at the microphones or  
from composite audio signals obtained by suitably combining  
15 said collected audio signals, thereby performing the echo  
cancellation.

48. An echo canceller as recited in claim 47, wherein  
the inputted first low-correlation audio signals are obtained  
20 by adding or subtracting the first audio signals of multi-  
channels with each other.

49. A multi-channel echo cancel method as recited in  
claim 1, wherein the multi-channel audio signals being  
25 inputted from an outside and having a correlation with each  
other are reproduced by said respective loudspeakers without  
lowering the correlation of the inputted multi-channel audio

signals.

50. A multi-channel echo cancel method as recited in claim 1, wherein the multi-channel audio signals being  
5 inputted from an outside and having a correlation with each other are provisionally modulated to lower the correlation, then demodulated to restore the correlation, and thereafter reproduced by said respective loudspeakers.

10 51. A multi-channel echo cancel method as recited in claim 50, wherein the multi-channel audio signals are provisionally modulated to lower the correlation by adding and subtracting the multi-channel audio signals with each other, or by orthogonalizing the multi-channel audio signals  
15 with each other.

52. An echo canceller being associated to a space provided therein with a plurality of loudspeakers and one or a plurality of microphones for forming a plurality of audio  
20 transfer systems, the echo canceller comprising:

an input section that inputs multi-channel audio signals from an outside, which have a correlation with each other, and which are reproduced by said respective loudspeakers as audio sounds having correlation with each  
25 other;

a generating section that generates reference signals as a set of low-correlation composite signals based

on said multi-channel audio signals, the low-correlation composite signals having a lower correlation with each other than that among said multi-channel audio signals;

an estimating section that estimates individual transfer functions of the respective audio transfer systems or composite transfer functions obtained by suitably combining said individual transfer functions based on the generated reference signals so as to set filter characteristics;

a filter section that produces echo cancel signals by applying said set filter characteristics to the multi-channel audio signals inputted from the outside or composite audio signals generated based on the inputted multi-channel audio signals; and

a subtracting section that subtracts said echo cancel signals from collected audio signals obtained by collecting the reproduced audio sounds having correlation with each other at the microphones or from composite audio signals obtained based on said collected audio signals, thereby performing the echo cancellation.